

MEMORANDUM

TO: Toni Jones, U.S. Environmental Protection Agency
FROM: Eastern Research Group, Inc.
DATE: November 20, 2011
SUBJECT: Reconsideration Proposal Compliance Cost Analyses for CISWI Units

BACKGROUND

The U.S. Environmental Protection Agency, under section 129 of the Clean Air Act (CAA), is required to regulate emissions of nine pollutants from Commercial and Industrial Solid Waste Incineration (CISWI) units: hydrogen chloride (HCl), carbon monoxide (CO), lead (Pb), cadmium (Cd), mercury (Hg), particulate matter (PM), dioxins/furans (PCDD/PCDF), nitrogen oxides (NO_x), and sulfur dioxide (SO₂).

On December 1, 2000, the EPA adopted new source performance standards (NSPS) and emission guidelines (EG) for CISWI units under Sections 111 and 129 of the Clean Air Act. In 2001 the EPA granted a petition for reconsideration regarding the definitions of "commercial and industrial waste" and "commercial and industrial solid waste incineration unit." In 2001, the United States Court of Appeals for the District of Columbia Circuit granted the EPA's voluntary remand, without vacatur, of the 2000 rule. In 2005, the EPA proposed and finalized the commercial and industrial solid waste incineration definition rule which, among other things, revised the definitions of "commercial and industrial waste" and "commercial and industrial waste incineration unit." In 2007, the United States Court of Appeals for the District of Columbia Circuit vacated and remanded the 2005 commercial and industrial solid waste incineration definition rule.

On March 21, 2011, the EPA promulgated revised NSPS and EG as its response to the voluntary remand that was granted in 2001 and the vacatur and remand of the commercial and industrial solid waste incineration definition rule in 2007. In addition, the standards re-development included the 5-year technology review of the new source performance standards and emission guidelines required under Section 129. Following that action, the Administrator received petition[s] for reconsideration and identified some issues that warranted further opportunity for public comment. In addition, data were received that enabled the EPA to revise the CISWI inventory of waste-burning kilns and energy recovery units to more accurately reflect the definition of non-hazardous secondary materials. The development of the MACT floors used to determine these options is discussed in more detail in a separate memorandum.¹ The purpose of this memorandum is to present for existing sources the nationwide costs and nationwide cost effectiveness associated with compliance with the proposed standards and alternatives to compliance.

This memo is organized as follows:

- I. Choosing Controls Needed for Each Unit to Meet MACT Floors
- II. MACT Compliance Costs
 - A. Emission Control Costs
 - B. Stack Testing, Monitoring, and Recordkeeping Costs
 - 1. Stack Testing
 - 2. Monitoring Requirements
 - 3. Recordkeeping and Reporting
 - C. Alternative Disposal Costs

III.	Cost Effectiveness
IV.	New Units
V.	References

I. CHOOSING CONTROLS NEEDED FOR EACH UNIT TO MEET MACT FLOORS

A significant portion of the total cost for industry compliance comes from the cost of installing new or improving existing pollution control devices for units not currently meeting the proposed limits. In order to determine the control costs, it was necessary to evaluate, for each CISWI unit, how much improvement for each pollutant would be needed to meet the proposed emissions limits.

In order to determine how much improvement would be needed for each unit, the maximum test average (i.e., the highest emission concentration) for each pollutant was determined for units having test data. This is assumed to be the basis that sources would base their control strategy on to ensure compliance with the standards. This is different from the overall pollutant average used to calculate baseline annual emissions² so that baseline emissions are not overestimated and more truly reflect the average performance of the unit. Similar to the gap-filling methodology for the baseline emissions calculations, data gaps were filled first by using the same measured data from similar units operated by the corporate entity. If these data were not available, then subcategory default values were assigned for the unit. These default values were the mean of all known units' maximum emissions test averages within each subcategory. Once every unit was assigned with a value, these values were compared with the MACT floor emissions limits, and percentages were calculated to quantify the amount of improvement needed for the unit to meet the MACT floors. Tables 1A – 1E contain the baseline pollutant concentration values used for each unit in each subcategory and the percentage improvement required to meet the emissions limits for each unit for each pollutant. The existing CISWI units are subcategorized into five main groups: energy recovery units (ERUs) designed to burn liquid or gas, ERUs designed to burn solids materials, incinerators, waste-burning kilns, and small, remote units. The pollutant- and subcategory-specific limits are shown in each header row of these tables. Note that in the solids-burning ERU subcategory, separate limits for coal-burning units and biomass-burning units were determined for carbon monoxide, lead, cadmium, filterable particulate matter, dioxin/furans, nitrogen oxides, and sulfur dioxides. In the waste-burning kilns category, separate limits for long kilns and preheater/preheater-precalfiner kilns were determined for carbon monoxide.

As discussed at proposal in 2010, control methods and cost algorithms utilized in a recent rulemaking for another waste combustion source category, Hospital, Medical and Infectious Waste Incinerators (HMIWI) were updated and utilized generally for the CISWI source category, since most of these algorithms are applicable to waste combustion units found in the CISWI source category. Since the 2010 proposal, there were two additional control technologies considered for use on CISWI units, duct sorbent injection followed by fabric filter (DIFF) and regenerative thermal oxidizers (RTO). Based on these required improvements, pollutant-specific control methods were chosen as follows for units unable to meet the MACT floors:

Metals (cadmium and lead) and PM: Adding fabric filters or improving existing fabric filters.

Mercury and dioxins/furans (PCDD/PCDF): Adding activated carbon injection (ACI) and adjusting the carbon addition rate to meet the amount of reduction required. Where ACI is required, a fabric filter would also need to be installed if the unit does not already have a fabric filter in place.

Hydrogen chloride (HCl): Adding wet scrubbers, or improving already installed wet scrubbers. For energy recovery units with average stack gas flow rates greater than 75,000 actual cubic feet per minute (acfm), a duct sorbent injection/fabric filter (DIFF) combination was prescribed instead of a wet scrubber as commenters argued that larger units would likely use this technology rather than a wet scrubber.

Carbon monoxide (CO): For incinerators and small remote units, an afterburner retrofit was the prescribed technology for CO control. For waste-burning kilns, the assumed control technology for CO control was addition of a regenerative thermal oxidizer (RTO). For energy recovery units, the control prescribed depended on the maximum CO test average of the unit. For liquid/gas-burning units, a tune-up was assigned for units under 36 ppmvd, advanced combustion controls (linkageless boiler management system) for units in the 36 to 96 ppmvd range, and a CO oxidation catalyst for units over 96 ppmvd. For biomass-burning units, a tune-up was assigned for units under 735 ppmvd, advanced combustion controls (linkageless boiler management system) for units in the 735 to 1,960 ppmvd range, and a CO oxidation catalyst for units over 1,960 ppmvd. For coal-burning units, a tune-up was assigned for units under 69 ppmvd, advanced combustion controls (linkageless boiler management system) for units in the 69 to 184 ppmvd range, and a CO oxidation catalyst for units over 184 ppmvd.

Nitrogen oxides (NO_x): Adding selective non-catalytic reduction (SNCR) systems.

Sulfur dioxide (SO₂): Adding wet scrubbers, or improving already installed wet scrubbers. For energy recovery units with average stack gas flow rates greater than 75,000 actual cubic feet per minute (acfm), a duct sorbent injection/fabric filter (DIFF) combination was prescribed. For energy recovery units adding DIFF and requiring greater than 70 percent improvement, a wet scrubber in addition to DIFF was prescribed, unless the unit already has a wet scrubber, in which case the addition of caustic to the existing scrubber was prescribed. If an energy recovery unit already having DIFF or SDA/FF installed cannot meet the limit, adding a wet scrubber as a polishing scrubber was assumed to be sufficient to meet the limit.

Further descriptions of these controls and their associated costs are listed below in Section II.

II. MACT COMPLIANCE COSTS

This section presents the nationwide costs estimated for existing CISWI for (A) the emission controls used to comply with the MACT floor; (B) the monitoring, testing, recordkeeping, and reporting activities used to demonstrate compliance; and (C) the alternatives to compliance. Total capital cost for all existing CISWI units to meet the MACT floor emission limits is estimated at approximately \$921 million. Total annual cost for compliance for all units in all subcategories is about \$285 million, but is about \$270 million for the lowest cost alternative. As presented above, the existing CISWI units are subcategorized into five main groups: liquid/gas-burning ERUs, solids-burning ERUs, incinerators, waste-burning kilns, and small, remote units. Tables 2A-2E present costs for emission controls, stack testing, monitoring, and reporting and recordkeeping for each unit within each subcategory, as well as costs for alternatives to compliance where applicable. Table 3 summarizes total compliance costs, as well as the lowest cost alternative (where alternative disposal methods are possible) for all units.

A. Emission Control Costs

Emission control technologies and other control measures that can be used to comply with the MACT floor options for existing CISWI units include wet scrubbers, fabric filters, selective non-catalytic reduction (SNCR), activated carbon injection (ACI), duct sorbent injection followed by fabric filter (DIFF), regenerative thermal oxidizers (RTO), oxidation catalysts and various other control measures designed to obtain incremental emission reductions. This section presents the costs that were estimated for each of these control measures.

The retrofit factors for the capital costs were assumed to be 40 percent for wet scrubbers, fabric filters, and 20 percent for SNCR and ACI.^{3, 4} Downtime costs for the retrofits were assumed to be negligible. Most CISWI are expected to be outdoors with adequate space to install an emission control system

without shutting down the incinerator for an extended period. Commenters have suggested that additional footprint required for controls for small remote incineration units in certain parts of Alaska may be costly to construct and permit. However, no data were provided that would assist in developing any cost adjustment factors to estimate additional footprint costs. It was also expected that connecting the ductwork could be performed during a scheduled downtime for maintenance, thereby minimizing expected downtime.⁵

The capital and annual costs for the emission controls were estimated in units of dollars (\$) and \$/flow. The \$/flow costs were calculated by dividing the capital/annual control cost estimate for each unit by the average gas flow rate assigned to that unit. Table 4A is a summary of the parameters used for each unit (e.g., incinerator charge rate, stack gas flow rate, incinerator operating hours, and concentrations). Additional information on the calculation of flue gas flow rates specifically for energy recovery units and waste-burning kilns can be found in Tables 4B and 4C.

Total capital cost for controls for all subcategories is estimated at approximately \$921 million, and total annual cost for controls for all subcategories is about \$285 million. Costs are on a 2008 basis, and annualized costs assumed an interest rate of 7 percent. Tables 5A-5J present a summary of the parameters and equations used in the cost algorithms for each emission control device.

1. Adding a fabric filter.

Fabric filters can be installed either alone or with other add-on controls. The cost algorithm for installing a fabric filter for waste-burning kilns, incinerators, and small remote incinerators is presented in Table 5A and is based on algorithms in the *Model Plant Description and Control Cost Report* for HMIWI.⁵ For energy recovery units, calculations were based on an algorithm originally utilized for HMIWI, but incorporating slight modifications to make them consistent with those being utilized by the boilers NEHSAP development to accommodate typically higher flue gas flow rates. Calculations specific to fabric filter installations for energy recovery units are presented in Table 5B. The fabric filter capital costs range from approximately \$767,000 to \$28.2 million, and annual costs range from approximately \$136,000/yr to \$6.1 million/yr. Sources for specific cost data are noted below Table 5A.

2. Adding a wet scrubber.

Wet scrubbers can be installed alone or after a dry scrubber/fabric filter. The cost algorithm for installing a packed-bed wet scrubber is presented in Table 5B and is based on algorithms in the *Model Plant Description and Control Cost Report* for HMIWI. The packed-bed wet scrubber capital costs range from approximately \$282,000 to \$9.6 million, and annual costs range from approximately \$77,000/yr to \$6.7 million/yr. Sources for specific cost data are noted below Table 5C.

3. Adding a selective non-catalytic reduction (SNCR) system.

In an SNCR system, a nitrogen-based reducing agent, or reagent, such as ammonia or urea, is injected into the post-combustion flue gas through nozzles mounted on the wall of the combustion unit. The cost algorithm for installing an SNCR system is presented in Table 5D and is based on algorithms in the *OAQPS Control Cost Manual*.³ The SNCR capital costs range from approximately \$48,000 to \$3.4 million, and annual costs range from approximately \$5,300/yr to \$379,000/yr. Sources for specific cost data are noted below Table 5D.

4. Adding an activated carbon injection (ACI) system.

Injecting activated carbon before the fabric filter has been demonstrated to improve the removal efficiency of both Hg and PCDD/PCDF from CISWI. The cost algorithm for installing an ACI system to incinerators, small-remote incinerators, and waste-burning kilns is presented in Table 5E and is based on algorithms in the *Model Plant Description and Control Cost Report* for HMIWI⁵. The cost algorithm for installing an ACI system to energy recovery units is presented in Table 5F and is based on algorithms in the *IPM Model - Revisions to Cost and Performance for APC Technologies, Mercury Control Cost Development Methodology*¹⁰. Adjustments to the carbon injection rate were made to account for how much reduction was required to meet the emission limit, and whether a packed-bed scrubber was either being added or would be improved, since scrubbers may also assist in reducing Hg emissions. The packed-bed scrubber adjustment is a ten percent Hg reduction, and is based on input from the boiler NESHAP development. The ACI factor compares the carbon grain loading originally assumed to achieve 90 percent control of mercury or 98 percent control of PCDD/PCDF to the amount of reduction the unit will need to meet the final emission limits. For the incinerator, small-remote incinerator, and waste-burning kiln subcategories, the highest factor (Hg or PCDD/PCDF) is then used to adjust the carbon injection rate calculation of the algorithm. For the energy recovery unit subcategories, the fuel-based fly ash waste rates are also included in the carbon injection rate calculation of the algorithm. However, the carbon injection rate is not a variable in this algorithm, so therefore was not adjusted based on the amount of reduction in Hg or PCDD/PCDF required to meet the emission limit. ACI capital costs range from approximately \$4,700 to \$160,000, and annual costs range from approximately \$3,400/yr to \$3.7 million/yr. Sources for specific cost data are noted below Table 5E and 5F.

5. Adding an afterburner/secondary chamber retrofit.

Afterburner, or secondary chamber, retrofits include retrofitting an incinerator with a larger secondary chamber (with a longer gas residence time, e.g., 2 seconds) and operating it at a higher temperature (e.g., 1800°F). The cost algorithm for installing an afterburner retrofit with an incinerator or small, remote unit is presented in Table 5G and is based on algorithms in the *Model Plant Description and Control Cost Report* for HMIWI.⁵ Afterburner capital costs range from approximately \$77,000 to \$451,000, and annual costs range from approximately \$15,000/yr to \$281,000/yr. Sources for specific cost data are noted below Table 5G.

6. Adding duct sorbent injection/fabric filter (DIFF).

Duct sorbent injection is a control technique for SO₂ control where a sorbent such as limestone is injected into the duct upstream from the particulate matter control device. The flue gas stream may be humidified and cooled to get the gas stream to the desired reaction temperature. In this instance, we have assumed a fabric filter is the particulate matter control device. Calculations were based on an algorithm originally utilized for HMIWI, but incorporating slight modifications to make them consistent with those being utilized by the boilers NESHAP development. Commenters have argued that energy recovery units with flue gas flow rates over 75,000 acfm would use DIFF control rather than wet scrubbers for acid gas control. Therefore, this control has been assumed for SO₂ control in these size energy recovery units. If the percent reductions exceed those expected from DIFF (70%), then a wet scrubber as a polishing step was also added to the control requirements for the unit, if no wet scrubber already existed for that unit. Calculations specific to DIFF installations for energy recovery units are presented in Table 5H. DIFF capital costs range from approximately \$6.7 million to \$33.4 million, and annual costs range from approximately \$1.9 million/yr to \$8.8 million/yr. Sources for specific cost data are noted below Table 5H.

7. Adding a regenerative thermal oxidizer (RTO).

Carbon monoxide control for waste-burning kilns may be accomplished using a regenerative thermal oxidizer (RTO). In this device, flue gas is pre-heated over ceramic media prior to the combustion chamber where the carbon monoxide is oxidized to carbon dioxide. The flue gas then exits the combustion chamber and transfers heat to the ceramic media to help preheat the incoming flue gas. This heat transfer helps reduce the amount of fuel needed to maintain combustion chamber temperatures required for oxidization. The cost algorithm for installing an RTO with a waste-burning kiln is presented in Table 5I and is based on cost analyses conducted for the final amendments of the Portland Cement NESHAP. RTO capital costs range from approximately \$6.0 million to \$19.5 million, and annual costs range from approximately \$1.5 million/yr to \$6.3 million/yr.

8. Incremental Controls.

In some instances, it may not be necessary to install a new control system to achieve the emissions reductions necessary to comply with the control options. An incremental reduction in emissions may be achievable by improving existing controls, such as increasing the amount of caustic used in the wet scrubber, increasing the flow of lime prior to the fabric filter, increasing wet scrubber horsepower, improving fabric filter performance, or increasing the amount of NO_x reagent injected into the post-combustion flue gas. Table 5J presents the algorithms used to determine the annual cost of these incremental controls. There are no capital costs for incremental controls. Sources for specific cost data are noted below Table 5J.

a. *Improving the performance of an existing fabric filter.*

One strategy to reduce PM and metals emissions further is to improve the performance of the fabric filter by replacing the filter bags used to capture emitted particulate. Costs to improve fabric filter performance were estimated using the same equations for bag and cage replacement employed in costing fabric filters and range from \$8,600/yr to \$257,000/yr.

b. *Increasing caustic.*

One strategy to reduce acid gas emissions further is to increase the amount of caustic used in the wet scrubber to react with and neutralize the acid gases in the gas stream. The addition of caustic is assumed to sufficiently reduce emissions without requiring any changes to the wet scrubber. Costs to increase the amount of caustic were estimated using the same caustic equation employed in costing packed-bed wet scrubbers and range from approximately \$350/yr to \$430/yr.

9. Additional Control Options.

a. *Adding advanced combustion controls.*

The costs to add a linkageless boiler management system (LBMS) are based on a 2008 quote provided to the U.S. Department of Energy. The installed cost for a LBMS on a 20 mmBtu/hr unit was \$19,127. The DOE noted that costs are relatively fixed, regardless of the size of the unit. Therefore, this cost was used as a fixed capital cost estimate for CISWI units required to add advanced combustion controls.

b. *Adding a CO catalyst.*

Cost estimates for adding a CO oxidation catalyst were based on the *Air Pollution Control Cost Manual*.⁸ Capital cost per unit ranges from \$452,000 to \$2.5 million, and annual costs range from \$195,000/yr to \$1.4 million/yr.

c. *Tune-up.*

Cost for performing a tune-up were based on a cost estimate provided in a report by Dr. H.M. Eckerlin and E.W. Soderberg⁹. This report indicated that the initial set-up for boiler tune-up was \$3,000 to \$7,000 per boiler, thereafter; annual tuning costs \$1,000 per boiler. An average \$5,000 per boiler initial set-up costs was annualized over 5 years at a 7 percent rate, and added to the subsequent year tune-up costs. Subsequently, an estimated flat cost of \$1,580 annually was applied for units requiring tune-ups.

B. Stack Testing, Monitoring, and Recordkeeping Costs

1. Monitoring Costs

Initial and continuous compliance provisions for CISWI units were selected to be as consistent as possible with comparable regulations. For energy recovery units, requirements were developed to be consistent with stack testing, monitoring, and recordkeeping requirements for major source boilers units adapted to reflect the CAA section 129 pollutants and provisions of section 129. For waste-burning cement kilns, monitoring requirements were based on the Portland Cement NESHAP and NSPS requirements for cement kilns and adapted to reflect the CAA section 129 pollutants. For the other three subcategories, requirements were as consistent as possible with current CISWI and HMIWI provisions. This section presents the costs that were estimated for each of these requirements.

The total capital cost for stack testing, monitoring, and recordkeeping and reporting for all subcategories is estimated at approximately \$8.8 million, and the total annual cost is about \$6.6 million per year. Cost estimates were based on algorithms recently utilized in the HMIWI regulatory development. Costs were updated to a 2008 basis, and annualized costs assumed an interest rate of 7 percent. Tables 6A-6E present a summary of the parameters and equations used in the cost algorithms for each monitoring component, where applicable.

a. *Inspections.*

Consistent with HMIWI regulations, it was assumed that annual control device inspections will be required for any units having control devices in place or requiring further controls to meet the MACT floors. In this context, control devices include fabric filters, afterburners, wet scrubbers, ACI systems, SNCR systems, DIFF, RTO, or oxidation catalysts. The cost was estimated at a flat rate of \$1000 per year. See Table 6A for further details and sources.

b. *Parameter monitors.*

Monitoring of operating parameters can be used to indicate whether air pollution control equipment and practices are functioning properly to minimize air pollution. Based on the existing CISWI regulations and HMIWI regulations, it was assumed that parameter monitoring will be mandatory for all units required to add fabric filters, wet scrubbers, SNCR systems, or ACI systems. Costs for each monitoring system were estimated as follows:

- For a fabric filter bag leak detection system, capital cost was estimated at \$25,500 and annual cost at \$9,700/yr.
- For a wet scrubber monitoring system, capital cost was estimated at \$24,300 and annual cost at \$5,600/yr.
- For an SNCR monitoring system, capital cost was estimated at \$10,300 and annual cost at \$3,200/yr.

- The cost for ACI monitoring depends on a unit's annual operational hours. There are no capital costs for ACI monitoring. Annual costs ranged from \$600 to \$10,100.
- While not reflected in the cost analysis, energy recovery units over 100 MMBtu/hr heat input will be required to operate a continuous oxygen monitoring system if they do not have one already. The capital cost for this system is estimated at \$8,523 and annual costs of \$1,436.

For default parameters and equations used for monitoring costs, see Table 6B. Sources for specific cost data are noted below the table.

c. *Continuous emissions monitoring systems (CEMS).*

The most direct means of monitoring compliance is the use of CEMS to measure the emissions of a pollutant on a continuous basis. The following text describes the CEMS for each subcategory of existing CISWI units that is included in the final regulation. The costs for Hg and PM CEMS are presented in Table 6B.

- For waste-burning kilns, it was assumed all units will require Hg CEMS, but that they would likely have installed these already to comply with the requirements of the Portland cement NESHAP. Capital cost was estimated at \$231,000 and annual cost at \$112,600/yr, but these were not applied to cement kilns.
- PM CEMS is required for energy recovery units having design capacities greater than 250 MMBtu. The capital cost for adding PM CEMS was estimated at \$158,000 and annual cost at \$56,100/yr.
- Continuous opacity monitoring is required for energy recovery units that don't have wet scrubbers, fabric filters with bag leak detectors, and have design capacities less than or equal to 250 MMBtu/hr. Cost was based on a quote from the Midwest Research Institute⁶ and adjusted to 2008 dollars. Capital cost was estimated at \$43,146 and annual cost at \$14,660/yr.

2. Testing Costs

a. *Initial Stack Testing.*

It was conservatively assumed that initial stack testing will be required for each pollutant for energy recovery units, incinerators, and small, remote units. Because PM, Hg, and HCl CEMS are required for cement kilns, it is assumed initial stack testing will be required for all pollutants except these. Additionally, initial opacity testing will not be required for kilns because of the PM CEMS requirement. Costs for each required stack test were summed and multiplied by 2/3 to adjust for economies of scale when multiple pollutant tests were being performed on a unit. The annualized costs were calculated assuming a capital recovery factor of 0.10979 (15 years at 7 percent). The basis of these cost estimates for each stack test is summarized in Table 6C.

b. *Annual Stack Testing.*

It was assumed that all units, to some extent, will be required to demonstrate ongoing compliance with the emissions limits for certain pollutants. Provisions in the final CISWI regulations indicate that testing for all pollutants must be conducted once, and if the resulting concentration for any of the pollutants is less than a certain threshold percentage of the emission limit, the source qualifies for reduced annual testing provisions for this pollutant. For the purposes of this cost analysis, the maximum annual testing requirement for each unit was assumed. Stack testing costs are presented in Table 6C.

c. *Visible emissions testing.*

All CISWI units except for cement kilns will likely have ash handling operations. Therefore, these units would be required to demonstrate compliance to a 5 percent visible emissions limit for fugitive emissions generated during ash handling (similar to HMIWI). We are requiring that energy recovery units, incinerators, and small, remote incineration units will be required to conduct annual performance tests for fugitive emissions from ash handling using EPA Method 22. Costs for this annual test include a capital cost of \$250 and an annual cost of \$200, based on the *Revised Compliance Costs and Economic Inputs for Existing HMIWI* memo.⁷ Further details regarding this cost estimate are included in Table 6D.

3. Recordkeeping and Reporting Costs

For all units, a flat rate of \$2,989 per year was estimated as the annual cost for recordkeeping and reporting. Further details regarding this cost estimate, including hourly labor assumptions, labor rates, and associated sources, are included in Table 6E.

C. Alternative Disposal Costs

Certain CISWI units may have waste disposal alternatives other than combustion available to them. These alternatives may prove to be less costly than the controls and monitoring required for compliance with the CISWI standards. For example, some facilities may be able to simply divert their waste to a landfill or municipal waste combustor (MWC). To attempt to quantify the alternate waste disposal costs, for incinerators and small, remote units, the cost of alternative waste disposal methods such as landfilling or hauling waste to a MWC were also estimated.

For incinerators, unit capacity, annual operating hours, and a default tipping fee and hauling cost, were used to calculate annual costs for landfilling the waste that would otherwise be incinerated. Annual landfilling costs varied widely, reaching a maximum of about \$2.5 million/yr. Table 7A summarizes the parameters and equations used to calculate these cost estimates.

An additional option for incinerators would be to haul the waste to an MWC. Unit capacity, annual operating hours, and a nationally averaged tipping fee were used to calculate annual costs, which ranged up to \$3.6 million. Table 7B presents the basis for these cost estimates. In most cases, hauling waste to an MWC was found to be cheaper than complying with the limits, but still more expensive than landfilling.

Commenters contended that the landfill cost algorithm used for the incinerator subcategory was not considered appropriate for small, remote units, due to the increased difficulty in transporting waste to landfills in these locations (e.g. weather, much longer distances, or the need for air or marine transport rather than hauling by truck). To account for this, the cost per ton of waste diverted was estimated at a flat \$15,000 per ton of waste diverted. This value is based on a half of the maximum estimate provided by

public commenters, since some units may be able to use conventional methods of transport whereas others may have the maximum cost to transport wastes. Annual landfilling costs for small, remote units ranged from \$433,000/yr to \$24.6 million/yr. Table 7C summarizes the parameters and equations used to calculate these cost estimates.

An additional option considered for small, remote units was waste segregation and add-on controls. It is generally less expensive for these facilities to segregate their waste and divert the nonferrous metal and chlorinated plastic to a landfill than to landfill all of their waste. This practice could allow them to meet the emission limits for mercury, HCl and PCDD/PCDF without having the need for add-on controls for these pollutants. Many facilities already practice some form of waste segregation, but would have to further expand their existing system to accommodate the broader range of materials to be segregated, primarily all metals and PVC from the waste stream. Annual costs for this option ranged from about \$4,000/yr to \$224,000/yr, and were calculated based on the waste disposal rate for the facility, the waste disposal costs indicated above and cost estimates facilities provided for implementing their existing waste segregation systems. The calculations for these costs are presented in Table 7C.

To calculate the overall annual cost for each alternative disposal option, the costs associated with operating the incinerator and the annualized capital cost of the unit must also be accounted for. To address this, annual incinerator operational costs were subtracted from the annual alternative cost plus the annualized incinerator cost. The algorithms used for calculating the operational cost and annualized capital cost of the incinerator are shown in Table 7D. Intermittent operation was assumed for incinerators burning at least 1 ton per year of waste, and batch operation was assumed for incinerators burning less than 1 ton per year of waste. Unit-specific incinerator operational costs, annualized incinerator cost, and alternative disposal costs are listed in Tables 2C and 2D.

III. COST EFFECTIVENESS

The cost effectiveness of the final emission limits was calculated for each subcategory by dividing the total compliance cost (emission control, monitoring, testing, recordkeeping, and reporting) by the total emission reduction (HCl, CO, Pb, Cd, Hg, PM, PCDD/PCDF, NO_x, and SO₂) needed to meet the emission limits. Note that the emission reductions were derived in a separate memorandum.² Tables 8A and 8B present the estimated cost effectiveness values for each subcategory, over all pollutants.

Table 8A shows the estimated costs and cost effectiveness for all units to meet the final emission limits. The nationwide average cost effectiveness for all units to meet the emission limits was estimated to be \$2,700/ton for liquid/gas-burning ERUs, \$17,200/ton for solids-burning ERUs, \$58,400/ton for incinerators, \$388,800/ton for small, remote units, and \$4,800/ton for waste-burning kilns. Over all subcategories, the average cost effectiveness was estimated to be \$8,300/ton.

Table 8B shows the estimated costs and cost effectiveness for units to choose the most inexpensive option. The nationwide average cost effectiveness for all units to choose the lowest cost option between complying using add-on controls and using an alternative disposal method was estimated as follows: \$2,700/ton for liquid/gas-burning ERUs, \$17,200/ton for solids-burning ERUs, \$7,600/ton for incinerators, \$234,800/ton for small, remote units, and \$4,800/ton for waste-burning kilns. Over all subcategories, the average cost effectiveness was estimated to be \$7,800/ton.

IV. NEW UNITS

Based on the results of our analysis for existing units and our experiences with other CAA Section 129 regulations, we do not anticipate that any new energy recovery units or waste-burning kilns will be constructed. Our experience with regulations for municipal waste combustors, HMIWI and, in fact, CISWI has shown that negative growth in the source category historically occurs upon implementation of CAA Section 129 standards. Since CISWI rules were promulgated in 2000 and have been in effect for existing sources since 2005, many existing units have closed. The EPA is not aware of any construction of new units since 2000, and therefore does not believe there are any units that are currently subject to the 2000 CISWI NSPS. Industrial or commercial operations considering waste disposal options for their facilities will likely choose not to construct new CISWI units and to use alternative waste disposal methods or alternative fuels that will not subject them to the CISWI rule. For example, new sources could engineer their process to minimize waste generation in the first place, or to separate wastes so that the materials sent to a combustion unit would not meet the definition of solid waste to begin with.

For incinerators and small remote units, on the other hand, it is more conceivable that some new units will be installed in the future, particularly in cases where alternative disposal methods are not a viable option and perhaps an older unit must be replaced. The total capital cost for new unit compliance over the next five years was estimated at approximately \$7.6 million, and annual costs at approximately \$2.3 million/yr. Tables 9A-9E summarize the assumptions and calculations made to estimate these costs.

In order to determine the costs for these potential new units to comply with the NSPS limits, it was necessary to determine what controls would likely be needed for the units. To do this, the average uncontrolled emissions resulting for each pollutant were calculated, using default control efficiencies in conjunction with the average baseline concentrations for each unit and its corresponding controls. These calculations are presented in Table 9A. This adjustment to represent uncontrolled units was unnecessary for small, remote units because none of these units currently have controls. A comparison of the average uncontrolled emissions with NSPS limits and the subsequent controls chosen are presented in Tables 9B and 9C.

To cost out control and monitoring costs, defaults were determined based on subcategory averages for all cost inputs. These default values are shown in Table 9D. The same algorithms used to calculate controls and monitoring costs for existing units were used for new units. It was assumed that 1 new incinerator would come into operation over the next five years, while 1 small, remote unit would come online each year for the next five years. Table 9E shows the cost breakdown for each subcategory. The capital cost for each new incinerator to comply was estimated at approximately \$3.3 million, and the annual cost was estimated at approximately \$788,000/yr. For small remote units, capital cost was estimated at approximately \$852,000 for each new unit to comply, with an associated annual cost of approximately \$310,000/yr.

V. REFERENCES

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11. APPENDIX A. TABLES FOR MACT FLOOR COST ANALYSES

The tables referenced throughout the body of this memo are presented in this section. They are organized as follows:

1. Percent Improvement Required to Meet MACT Floor
 - 1A: Energy Recovery Units – Liquid/Gas
 - 1B: Energy Recovery Units – Solids
 - 1C: Incinerators
 - 1D: Small, Remote Units
 - 1E: Waste-burning Kilns
2. Costs to Meet MACT Floor
 - 2A: Energy Recovery Units – Liquid/Gas
 - 2B: Energy Recovery Units – Solids
 - 2C: Incinerators
 - 2D: Small, Remote Units
 - 2E: Waste-burning Kilns
3. Summary of MACT Compliance and Alternative Disposal Costs
4. Input Parameters for Control Cost Algorithms
5. Control Cost Algorithms
 - 5A: Fabric Filter
 - 5B: Detailed Fabric Filter Costs for Energy Recovery Units
 - 5C: Packed-Bed Scrubber
 - 5D: Selective Non-Catalytic Reduction (SNCR)
 - 5E: Activated Carbon Injection (ACI) for Incinerators and Waste-Burning Kilns
 - 5F: Activated Carbon Injection (ACI) for Energy Recovery Units
 - 5G: Afterburner Retrofit for Incinerators
 - 5H: Dry Sorbent Injection/Fabric Filter (DIFF)
 - 5I: Regenerative Thermal Oxidizer (RTO)
 - 5J: Incremental Controls
6. Stack Testing, Monitoring, and Recordkeeping Costs
 - 6A: Maintenance and Inspection
 - 6B: Monitoring
 - 6C: Stack Testing Costs
 - 6D: Visible Emissions Testing
 - 6E: Recordkeeping and Reporting
7. Alternative Waste Disposal Algorithms
 - 7A: Cost to Haul Waste to Landfill
 - 7B: Cost to Haul Waste to Municipal Waste Combustor
 - 7C: Cost to Segregate Wastes and Landfill for Small, Remote Units
 - 7D: Cost to Continue Incinerator Operation
8. Cost Effectiveness of MACT Floors: Overall and by Subcategory

9. New Units: Cost to Meet MACT Floor

- 9A: Average Uncontrolled Incinerator Emissions
- 9B: Incinerator Emission Averages and Required Controls
- 9C: Small Remote Unit Emission Averages and Required Controls
- 9D: Default Cost Algorithm Inputs
- 9E: Control and Monitoring Costs for New Units